Claims

What is claimed is:

1. An apparatus for measurement of Raman scattered radiation comprising;

a) at least one source of electromagnetic radiation for producing an electromagnetic radiation beam characterized by a narrow spectral width;

b) an integrating cavity having an interior and an exterior, wherein a sample is placed in said interior, said integrating cavity having at least one port for insertion of said sample in said interior and for transmission of said electromagnetic radiation into and out from said interior, said at least one port extending from said exterior to said interior of said integrating cavity

c) a first optical element for transmitting said electromagnetic radiation into said interior of said integrating cavity through said at least one port;

d) a second optical element for collecting Raman scattered electromagnetic radiation from said sample through said at least one port;

e) a spectrum analyzer for determining spectral composition of said Raman scattered electromagnetic radiation;

f) a detector for measuring said Raman scattered electromagnetic radiation; and

g) a system for determining concentration of at least one chemical compound from measured Raman scattered electromagnetic radiation.

2. The apparatus according to claim 1 wherein said source of electromagnetic radiation is selected from the group consisting of a laser, a light emitting diode (LED) and a superluminescent diode.

3. The apparatus according to claim 1, further comprising a radiation expanding element for expanding said electromagnetic radiation beam before said electromagnetic radiation beam comes into contact with said sample.

4. The apparatus according to claim 1 wherein said integrating cavity is comprised of electromagnetic radiation scattering material of sufficient thickness to

back scatter a sufficient amount of electromagnetic radiation into said interior of said integrating cavity to enhance production, and analysis, of Raman scattered radiation with said spectrum analyzer and detector.

5. The apparatus according to claim 4 wherein said electromagnetic radiation scattering material is comprised of electromagnetic radiation scattering material selected from the group consisting of: an electromagnetic radiation scattering opalescent glass, an electromagnetic radiation scattering polytetrafluoroethylene (PTFE), an electromagnetic radiation scattering SPECTRALON™, an electromagnetic radiation scattering TEFLON™, an electromagnetic radiation scattering ceramic, and any other material of similar optical properties.

6. The apparatus according to claim 1 wherein said interior is delimited by an internal surface which is comprised of an electromagnetic radiation scattering coating of sufficient thickness to back scatter a sufficient amount of electromagnetic radiation into said interior of said integrating cavity to enhance production and analysis of Raman scattered radiation with said spectrum analyzer and detector.

7. The apparatus according to claim 6 wherein said electromagnetic radiation scattering coating is comprised of electromagnetic radiation scattering material selected from the group consisting of: an electromagnetic radiation scattering polytetrafluoroethylene (PTFE), an electromagnetic radiation scattering SPECTRALON™, an electromagnetic radiation scattering TEFLON™, an electromagnetic radiation scattering ceramic, a layer of electromagnetic radiation scattering MgO, $BaSO_4$, and any other material of similar optical properties used for surface coating of integrating spheres.

8. The apparatus according to claim 1 wherein said interior is delimited by an internal surface which is comprised of a redistribution structure and coated with at least one thin layer of an optical material that enhances reflection.

9. The apparatus according to claim 8 wherein said optic material is selected from a group consisting of: aluminum, silver, gold, multiple dielectric layers, and any other layers used in the field for reflection enhancement and surface protection.

10. The apparatus according to claim 1 wherein said integrating cavity is made of a material transparent for electromagnetic radiation with an internal, an external or both internal and external surface comprising a redistribution structure, wherein said internal, said external, or both of said internal and external surface is covered with at least one layer of a reflection enhancing material selected from group consisting of: aluminum, silver gold, multiple dielectric layers, and any other layers used in the field for reflection enhancement and surface protection.

11. The apparatus according to claim 1 wherein said first optical element and said second optical element are selected from the group consisting of a lens, a mirror, a radiation guiding element, and a combination thereof.

12. The apparatus according to claim 11 wherein said radiation guiding element is an optic fiber.

13. The apparatus according to claim 1 wherein said spectrum analyzer is selected from the group consisting of a spectrometer, A Fourier transform spectrometer, a turntable filter, an acousto-optic turntable, and a variable transmittance filter.

14. The apparatus according to claim 1 wherein said detector is selected from the group consisting of a linear diode array, a CCD, a photodiode, and a photomultiplier.

15. The apparatus according to claim 1, wherein said system for determining concentration of at least one chemical compound from measured Raman scattered electromagnetic radiation comprises a computer comprising at least one calibration algorithm.

16. The apparatus according to claim 3 wherein said radiation expanding element is selected from a diffusion wall and a lens or a combination thereof.

17. The apparatus according to claim 16, wherein said diffusion wall comprises at least one aperture, said at least one aperture located outside a cross sectional area of said electromagnetic radiation impinging on said diffusion wall.

18. The apparatus according to claim 16, wherein said diffusion wall comprises a material selected from the group consisting of: an electromagnetic radiation scattering polytetrafluoroethylene, an electromagnetic radiation scattering SPECTRALON™, an electromagnetic radiation scattering TEFLON™, an electromagnetic radiation scattering ceramic, an electromagnetic radiation scattering opalescent glass, a coated glass, a coated fused silica, a coated quartz, a coated sapphire, a coated transparent plastic, an electromagnetic radiation non-absorbing material, and one or more of said material with a redistribution structure on one or both surfaces.

19. The apparatus according to claim 1 wherein said integrating cavity comprises at least 2 ports and wherein said first and said second optical element are each coupled with a different port.

20. The apparatus according to claim 18, wherein the said first optical element is coupled to integrating cavity with two or more ports.

21. The apparatus according to claim 18, wherein there are more than two ports coupled to said second optical element.

22. The apparatus according to claim 1 wherein said interior comprises at least one diffusing wall separating said integrating cavity into a diffusing chamber and a sample chamber, said sample chamber for receiving said sample, said diffusion chamber and said sample chamber each comprising at least one port extending from said exterior to said interior and wherein said first optical element is optically coupled

with said diffusing chamber and said second optical element is optically coupled with said sample chamber.

23. The apparatus according to claim 22 wherein said diffusion wall comprises a material selected from the group consisting of an electromagnetic radiation scattering opalescent glass, polytetrafluoroethylene, SPECTRALON™, TEFLON™, an electromagnetic radiation scattering ceramic, a coated glass, a coated fused silica, a coated quartz, a coated sapphire, a coated transparent plastic, an electromagnetic radiation non-absorbing material, and one or more of said material with a redistribution structure on one or both surfaces.

24. A method for measuring a concentration of one or more chemical compounds in a sample using Raman scattering comprising;

a) placing said sample within an integrating cavity;

b) generating an electromagnetic radiation beam characterized by a narrow spectral width and transmitting said electromagnetic radiation into said integrating cavity;

c) spreading said electromagnetic radiation beam before said radiation comes into contact with said sample to produce an expanded beam having a specific radiation power density smaller than a predetermined tolerance limit for said sample;

d) collecting said Raman scattered electromagnetic radiation from said sample within said integrating cavity;

e) spectrally decomposing said Raman scattered electromagnetic radiation

f) measuring said Raman scattered electromagnetic radiation; and

g) determining said concentration of said one or more chemical compounds.

25. The method according to claim 17, wherein said sample is a digit.

26. The method according to claim 18 wherein said digit is a finger.

27. The method according to claim 19 wherein said known substance is glucose.

28. The method according to claim 17 wherein said integrating cavity comprises at least one diffusing wall separating said integrating cavity into a diffusion chamber and a sample chamber, said diffusion chamber and said sample chamber each comprising at least one port extending from said exterior to said interior and wherein in step b) said sample is placed in said sample chamber, in step c) said electromagnetic radiation is transmitted into said diffusing chamber through said at least one port of said diffusing chamber and in step d) said Raman scattered electromagnetic radiation is collected from said sample through said at least one port of said sample chamber.

29. An integrating cavity comprising:

a) an interior and an exterior, wherein a sample is placed in said interior of said integrating cavity, said integrating cavity having at least one port for insertion of said sample in said interior and for transmission of electromagnetic radiation into and out from said integrating cavity, said at least one port extending from said exterior to said interior of said integrating cavity, and

b) a radiation expanding element for expanding said electromagnetic radiation beam before said electromagnetic radiation beam comes into contact with said sample.

30. An apparatus comprising an integrating cavity optically coupled with a spectral analyzer and detector for analysis and measuring Raman scattered electromagnetic radiation.